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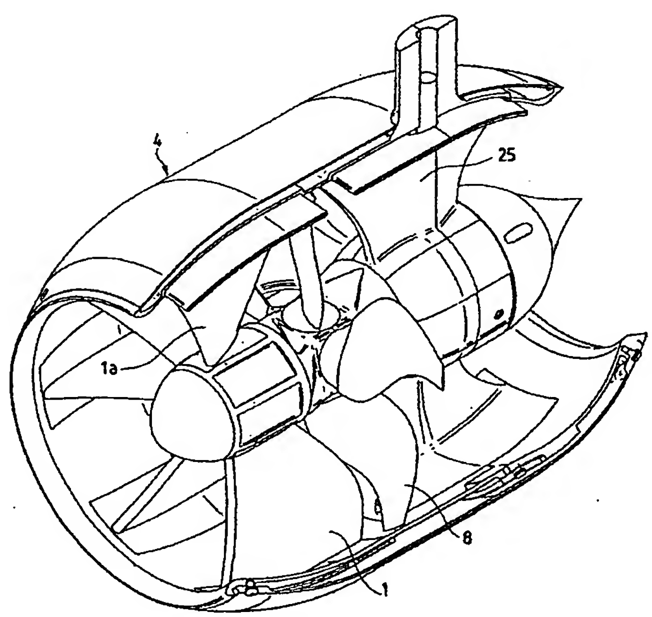

(57) **Abstract:** A turbine engine, particularly for aircrafts, of the type comprising a rotor and at least two stages of stator blade rows positioned upstream and downstream of the rotor, wherein the rotor blades (8) are of the variable pitch type and have a drop shape, are of the twisted type (1) or of the constant deflection type (2) and the stator blades (25), positioned downstream of the rotor, are of the twisted type.

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A TURBINE ENGINE

This invention refers to a turbine engine with variable pitch rotor blades having a drop shape; the engine according to the invention can advantageously also incorporate a "twisted" or a "constant deflection" stator blade row in the Air-Intake and, in the nozzle, a stator blade row with a movable twisted part.

This propulsion system, wherein the movable parts are controlled and actuated electrically, can be employed both for the aeronautic propulsion and for the marine propulsion.

Currently, the turbine engines utilised in propulsion are predominantly of the Turbo-Engine type; as it is known, in this type of engines a turbine/compressor group rotates a power shaft to which a fixed pitch propeller located at the end of a divergent duct is connected; this duct called Air-Intake, usually free of stator blades, has the scope to decelerate the air processed by the rotor in order to increase the efficiency.

This propulsion systems have the same limits of the fixed pitch propeller, which can be summarized as follows:

1. the efficiencies decrease very rapidly above defined speeds V of advancement;

2. the resultant of the applied forces coincides at the end of the blades, with consequent bending stresses which alter the system aerodynamics.

In the Engines with ducted propellers, which have the scope to generate a thrust useful for the propulsion, none of the expedients which are proposed and justified in this analysis has been utilised.

In some jet engines, stator blade row (in some cases with movable twisted part) are located upstream of the rotor in the stages of the axial compressors, but to vary the performance modifying the pressure and to avoid the stall.

The variable pitch technique is instead widely utilised but only in the outside propellers for reasons that will be discussed hereinafter.

The turbine engine, with the drop shaped, variable pitch rotor blades, that is the object of this application, as claimed in claim 1, is proposed as a device capable to supply more efficiency than any other propulsion system of similar conception.

We will now describe the engine according to the invention, with reference to the attached drawings, in which:

Figures from 1 to 8 are mathematical vectorial models;

Figure 9 shows a twisted stator blade from the a), b), c) and d) views which are the plan, front, side and perspective views, respectively;

Figure 10 shows a constant deflection stator blade from the a), b), c) and d) views which are the plan, front, side and perspective views, respectively;

Figure 11 is an exploded, perspective view of the propeller cuff with the twisted stator blade;

Figures 12a, 12b and 13a are the exploded, assembled and sectional views of a rotor with variable pitch blades according to the invention;

Figure 13b is a view of the variable pitch blade according to the invention;

Figures 14a and 14b are partially assembled and exploded views, respectively, of the stator part downstream of the rotor;

Figures 15a and 15b are partially assembled and exploded views, respectively, of the engine casing downstream of the rotor;

Figure 16 is the axial sectional view of the stator part and of the engine casing downstream of the rotor;

Figures 17a and 17b are assembled and exploded views, respectively, of the stator part downstream of the rotor;

Figures 18, 19, 20 and 21 are efficiency diagrams;

Figures 22 and 23 are axial sectional views of the full engine according to the invention.

Now, we will see in details how we arrived to the invention and which are the concrete advantages in relation to the known art. To do so, we start from the mathematical models known in this sector.

The field diagram is a vectorial diagram where all the speed triangles of each station can be represented, simultaneously, in a working condition; for simplicity, in the enclosed figures, only the triangles related to the stations on the hub (indicated by "m") and at the end (indicated by "e") are represented.

The main scope of this diagram is to define with ease the dimensions of the twist of the propeller, either ducted or unducted; the twist angles θ of the various airfoils, are the angles subtended by the vectors that represent the driving speed U and the relative speed W, defined, in the propeller wing theory, with the symbol β (appropriately calculated in the design phase as we can suppose from Figure 1).

The values of the advancement speed V and of the driving speed U are reported in this diagram, by changing them from m/sec to cm.

The reference to build this diagram is the rotation axis of the propeller indicated in the figure with the initials A.r.. The driving speed U vectors are perpendicular to A.r., they are opposite to the propeller rotation vector (we consider, for the reciprocity principle, the blade in a steady state and the air flowing on it), proportional to the station taken in consideration and dependent from the number of the rotor revolutions.

The advancement speed vector V depends instead from the type of the studied propeller:

- for outside propellers and for ducted propellers, without stator stages upstream of the rotor, it is always parallel to A.r.;
- for ducted propellers, supplied with stator blading located in the Air-Intake, it is deviated by λ degrees and depends from the stator type (twisted or with constant deflection).

In Figure 2 a field diagram is represented which gives the scheme of the presence of a stator twisted blading (to be noted how, at the hub, V is deviated of λ_m degrees with respect to A. r., while at the end it is parallel).

In Figure 3 a field diagram is represented which gives the scheme of the presence of a stator twisted blading which deviates the flow lines, at each station, of λ degrees.

As shown in Figure 4, in a duct, positioned downstream of the stator blade row which deviate the direction of the flow lines of λ degrees, the speed vector V' is the vectorial sum of the axial speed V and of a component τ which is generated perpendicularly; in fact the axial speed V of the particles contained in a constant section duct can not change otherwise the flow rate would change.

Let's clarify the base theory on which the Engine, according to the invention, is based by introducing the concepts of

efficacy E and of efficiency η of the propeller and by linking said concepts to the field diagram.

The propulsion efficacy E is defined as the ratio between the driving force T developed by the propeller and the resisting force F_r which resists to the propeller rotation. T and F_r are respectively the forces which act along the parallel and the perpendicular direction to the rotation axis of the rotor; they are equal, in module, to the algebraic sum of the vectorial components of the Lift L and of the Drag D along said directions.

With reference to Figure 5, we can then write the following relations valid in each section of the blade:

$$T = L\ \cos\beta - D\ \sin\beta = ½\ \rho\ S\ W^2\ (C_l\ Cos\beta - C_d\ Sin\beta\ )$$

$$F_r = D\ \cos\beta + L\ \sin\beta = ½\ \rho\ S\ W^2\ (C_d\ Cos\beta + C_l\ Sin\beta\ )$$

where ρ is the density, S is the area, W is the relative speed and C_l and C_d are the lift and drag coefficients, respectively.

By indicating explicitly the terms from which the propulsion efficiency depends and through appropriate passages we have:

$$E = \frac{T}{Fr} = \frac{(C_l / C_d) - Tg\beta}{(C_l / C_d) Tg\beta + 1}$$

As it can be seen from this last relation, the lower the value of β and the higher the efficiency value.

The efficiency η instead is defined as the ratio between the work yield and the work spent:

$$\eta = L_{yield} / L_{spent} = TV / C\omega$$

Where T is the Propeller driving force, V is the advancement speed, C is the torque needed by the rotatory movement and ω is the angular speed.

Knowing that, at each reference station, the value of the torque needed to rotate the blade is the product between the drag force and the distance from the rotation axis R, on which Fr acts (the total torque is the sum extended to the all area of the blade C = $\sum F_r R$) and by recalling that U = ωR, the formula of the efficiency η becomes:

$$\eta = \frac{TV}{C\omega} = \frac{TV}{\Sigma F_r R\omega} = \frac{TV}{\Sigma F_r U} \alpha E \frac{V}{U}$$

As it can be seen, η is proportional to the efficacy E and should increase in relation to the increase of the speed V because U is limited by the maximum number of revolutions: in reality the efficiency increases until a certain value of V, but then it starts to decrease because the increase of V increases the angles β which cause the value of the efficacy to decrease more than the increase of the ratio V/U.

The values of η are generally referred to the ratio of advancement γ (proportional to the ratio between the advancement speed V and the number of revolutions n) and typically have the path shown in Figure 6.

The base idea, at this point, is to increase the efficiency by introducing stator blades in the Air-Intake to reduce the value of β.

By analysing the field diagram of a traditional Engine, shown in Figure 1, it can be seen how β_m is larger than β_e; we then rotate the advancement speed V vector, at the hub station, by λ_m degrees so that the vector W_m becomes parallel to W_e (figure 2). The same procedure is repeated (but not shown) for all the sections taken as a reference.

We have introduced in this way a twisted stator that, in the design conditions of the stator twist, cause, in all the sections, the angles β equal to the value present at the end of the blade, where it has been demonstrated that there is the highest efficiency. Figure 2 represents the design technique of the stator twist: in the design condition (identified by the ratio of advancement Υ_{ps}) the stator airfoils must deviate the advancement speed V so as to generate relative speed vector W always equal, in module and in direction, in all the sections.

Supposing that Figure 7a identifies the design condition of the stator twist (identified by the advancement ratio Υ_{ps}) and knowing that the angles λ stay constant for all the situations, we can notice that, in the Engine according to the invention, with values of Υ lower than Υ_{ps} (Fig. 7/b) the

angles β are a little bit larger close to the hub; on the contrary, with values of γ higher than γ_{ps} (Fig. 7/c) the angles β are even smaller. It is clear then that the total efficiency is higher in the version proposed at the beginning, since, with the same working conditions, the values of β are smaller in the Engine according to the invention, if compared with the values of the modern propulsion systems.

In the version of the Engine according to the invention with constant deflection stator blading (Fig. 3), the value of the angles β, in all the sections of the blade, have also a value lower than the values of the Engine and of the Propeller blades; it is clear that, also in this version, the efficiency is optimised.

In the Engine according to the invention, with twisted stator blading, blades having the surface concentrated towards the hub are used, primarily for two reasons which can be understood from Figure 7:

- the value of the aerodynamic forces is directly proportional to the square of the relative speeds W which have a value, in module, always higher towards the hub with respect to the Engine (even with values higher than γ_{ps}, the modules of the vectors W at the hub are higher than the vectors at the end of the blade).

- with values of the advancement ratio higher than γ_{ps}, (cruise conditions) the airfoils at the hub work with efficiencies higher than at the end (β_m lower than β_e).

Therefore, in the Engine according to the invention with the twisted stator blading, besides an increase in the efficiency, the resultant of the aerodynamic forces generated by the blades is applied closer to the hub and the value of the centrifugal force relative to the blades has a lower value since the mass is concentrated closer to the centre of rotation; consequently, the structural stresses are lower.

Further, in the Engine according to the invention with the twisted stator blading, the chords of the blade can be dimensioned so as to obtain (at least in a certain condition) an elliptic distribution of the lift that, according to the Aerodynamic Theory, generates a value of produced Drag lower than any other type of distribution.

Going to conclude the description of the stator blading located in the Air-Intake, we call the attention to Figures 9, 10 e 11 which show, respectively:

- the Engine version according to the invention, with the twisted blade 1 in the plan (a), front (b), side (c) and perspective d) views;

- the Engine version according to the invention with the constant deflection blade 2 shown in the same views of the twisted blade in the preceding figure;

- the assembly of the blades according to the invention in the Air Intake 4 and in the propeller cuff 3 which can be split in two pieces; the scope of the hole 5 in the blade 1a is to form a passage for electric wires of the slip-rings.

The use of the variable pitch propeller in the engine according to the invention is motivated by the benefits that can be obtained and that are described here below:

1. A variable pitch propeller, under all circumstances, can be positioned in the best conditions with respect to the field of instantaneous speed ε (angle comprised between the relative speed vectors W_e and W_m, shown in Figures 1, 3 and 8b) so as that all airfoils always work at the maximum efficiency;

- a variable pitch propeller can obtain advancement speed V higher than the fixed pitch propellers (in fact if a fixed pitch propeller is dimensioned for high speeds V, the stagger angle would be so high that with low values of V the airfoils would go in stall conditions; on the contrary, in the variable pitch propeller, even if the twist of the blade is dimensioned for high values of V, at low speeds, the blade

can be positioned so that all the sections work at incidence angles which do not cause the stall);

3. a variable pitch propeller, at any time, can work as a brake or as a thrust reverser (on the contrary a normal blade can work as a brake only when the angles β are higher than the airfoils stagger angles).

It is evident that the variable pitch propellers are widely utilised in many aircrafts but they do not have yet find an application in the Fan.

The proposed variable pitch system, which is activated by an electric motor, is of the screw/female thread type and is contained in the rotor represented by Figures 12a, 12 b, and 13a in an exploded, assembled and sectional view, respectively.

The rotor is formed by four parts 6a, 6b, 6c and 6d which contain, in circular housings 7 (Fig. 12a), obtained in the transverse sections having a polygonal section, the blades 8; in the part 6c, helicoidal cavities 9 (Fig.12b) are obtained in order to balance the geometry change, from the circular to the polygonal shape, by directing the fluid toward the blades with the maximum efficiency.

The motor 10 is directly connected to a planetary gearbox 11 and to an encoder 12 and is powered by a slip-rings (not shown) linked close to the front bearing. The reduction gear

shaft 11 is linked to a worm screw (formed by the parts 12 and 13) on which a threaded ring nut 14 moves by rotation; the bushes 16 (connected to the eccentric arms 18 of the plate 19 by means of elastic rings 17) are retained in the groove 15 obtained in the ring nut 14. When the ring nut 14 moves axially, the plate 19 causes the blade 8 to rotate, transferring the rotation from the cavities 20 to the slots 21 (see Figure 13b).

The axial loads transferred from the ring nut 14 to the screw (12 and 13) are unloaded on the rotor parts 8b and 8c through axial roller bearings 22 (Figure 12a). The centrifugal force due to the blade 8 and to the related components is instead unloaded on the rotor parts 6c and 6d through the axial roller bearings 23 (Figure 13b). The drop shaped blade 8, comprised in the rotor 6, is also represented in Figure 8a (in a side and in a sectional view); the typical shape of the blade plan is obtained by locating some of the pressure centres of the airfoils Cp (points on which the resultants of the aerodynamic forces are applied) upstream and others downstream of the variable pitch rotation axis x, so that the torques, which are generated because of the aerodynamic forces, balance each other, thus allowing the use of a low power input to activate the variable pitch. The airfoils on the hub and at the end are positioned so that the axis x coincides with the centre line of the chord; while the other

airfoils are positioned so that, under all circumstances, the resulting torque change within a minimum value range; therefore the line that joins the Cp of all the blade airfoils, has the typical sinusoidal path shown in the side view of the blade of Figure 8a.

The bottom of the blade is circular and it is housed in the circular cavities 7 obtained in the rotor parts 6c and 6d; in this way the formation of the Von Karman vortices, which would reduce the efficiency, is avoided, see Figure 12.

We have discussed the twist technique of the stator blades 1 with the help of the field diagram; then, we will show, as an example, how to determine the twist of the blades 8.

Known the values of the stator defection λ, obtained under the conditions of the advancement ratio γ_{ps}, we have first of all to decide the value of the design advancement ratio of the rotor twist (γ_{pr}). From Figure 7, it is clear that, in order to obtain positive incidence angles in all the sections, γ_{pr} must be lower than γ_{ps}; the optimal value will depend from the outer diameter of the blades and from the advancement speed V that we intend to reach.

The twist condition is that, once defined the stator deflection angles and the value of γ_{pr}, the twist angles θ, in all the sections of the blade 8, coincide with the angles β; in this situation, as it is shown by the speed triangles,

adjacent to the sections A-A, B-B, e C-C of Figure 8a (extrapolated from the field diagram of Figure 8b), the airfoil chords are parallel to the relative speed vectors.

The function of the stators downstream of the rotor is to eliminate the swirl of the fluid flow rate processed by the rotor in order to increase the pressure and therefore the thrust.

The movable twisted part, in the stator blade row downstream of the rotor, is necessary to reduce to a minimum the pressure losses and the structure stresses; in fact the speed range ε out from the rotor is not constant during time but it changes both in amplitude and in orientation, with respect to the reference system common to both conditions.

This means that, by dimensioning the twist of the movable part, under proper design conditions, and by controlling the position of the surfaces (so that the airfoil chords form incidence angle values which are almost zero), we obtain, on said surfaces, reduced energy dissipation and undesired aerodynamic forces in comparison with the case where fixed surfaces would be used.

The exploded and assembled view of such device are represented in Figures 14 e 15; the side sectional view is instead shown in Figure 16.

The movable parts of the stators are driven by the electric motor 24; the blades 25 have, at their free ends, projecting folded levers 26, whose axis x is rigidly connected to the rotation centre of the blades 25. The projecting ends of the levers 26 are housed in eyelets obtained in the ring gear 28; said ring is linked to the outer structure 4 of the engine by means of the shoulders 29 and of the pins 30 obtained on the outer structure (See Figure 15b).

When the motor 24 rotates, by means of a coupling with conic gears (28 and 31), also the ring 28 rotates and, by dragging the levers 26, causes the blades 25 to rotate.

The actuation and the control of the movable surfaces is done by electric means, because this type of technology allows a better working flexibility and a better precision on the positioning: an electronic central unit processes, as input data, the advancement speed and the number of revolutions of the propeller and, thanks to the software with which the central unit is programmed, it drives the two electric motors which move the rotor pitch mechanisms and the pitch mechanisms of the movable stator part, respectively.

The positions of the blades 8 and 25 are respectively activated through the feedback by the encoders 12 (Figure 13a) and 32 (Figure 16) which send to the central processing unit a comparison electric signal which is proportional to the instantaneous position.

The rotor is set in rotation by a conic couple of gears, contained in the gear oil sump 33, by means of a power shaft 34 contained inside the stator blades downstream of the rotor (see Figure 17). The rotor is linked to the gear oil sump 33 and to the propeller cuff 3 by means of ball or roller angular bearings mounted with a "O" disposition.

The control of the propeller pitch is different from that of the movable part of the stator because there is the possibility to position, through a control in the cockpit, the blade at an offset angle with respect to the position controlled by the central unit, this control allows the pilot to manage directly the performances of the propulsion system. This control procedure is valid within the stall limits.

We conclude the theory description of the innovations introduced in the Engine according to the invention, by showing the diagrams of the efficiency represented in Figures 18, 19, 20 e 21 which refer to a fixed pitch Fan, to a variable pitch Fan, to a variable pitch Fan according to the invention with constant deflection stator blades and to a variable pitch Fan according to the invention with twisted stator blades, respectively.

The diagrams clearly summarize the advantages that the proposed and explained innovations make happen in the Engine according to the invention with respect to the current art of the Fan available on the market.

Finally, Figures 22 and 23 show the engine according to the invention (dimensioned and complete with all the needed parts).

Claims

1. A turbine engine, particularly for aircrafts, of the type comprising a rotor and at least two stages of stator blades positioned upstream and downstream said rotor, characterized in that the rotor blades (8) are of the variable pitch type and have a drop shape.

2. A turbine engine according to claim 1, characterized in that the stator blades (1), positioned before the rotor, are of the twisted type.

3. A turbine engine according to claim 1, characterized in that the stator blades (2), positioned before the rotor, are of the constant deflection type.

4. A turbine engine according to claim 1, characterized in that the stator blades (25), positioned after the rotor, are of the twisted type.

5. A turbine engine according to claim 1, characterized in that the variable pitch of the rotor blades (8) is activated by an electric motor (10) which controls a screw female thread system contained in the rotor; said rotor is formed by four parts (6a, 6b, 6c and 6d) which contain, in circular housings (7) obtained in the transverse sections with polygonal section, the blades (8); in one of the four parts (6c), helicoidal cavities (9) are obtained which balance the geometry change, from the circular to the polygonal shape, by directing the fluid toward the blades.

6. A turbine engine according to claim 5, characterized in that the motor (10) is directly connected to a planetary gearbox (11) and to an encoder (12) and is powered by a slip-rings; the reduction gear shaft (11) is linked to a worm screw on which a threaded ring nut (14) moves by rotation; the bushes (16), connected to the eccentric arms (18) of the plate (19) by means of elastic rings (17), are retained in the groove (15) obtained in the ring nut (14).

7. A turbine engine according to claim 1, characterized in that the rotor is set in rotation by a conic couple of gears, contained in a gear oil sump (33), by means of a power shaft (34) contained inside the stator blades which are positioned downstream of the rotor; said rotor is linked to the gear oil sump (33) and to the propeller cuff (3) by means of ball or roller angular bearings mounted with a "O" disposition.

8. A turbine engine according to claim 1, characterized in that the typical drop shape of the blade plan, contained in the rotor (6), is obtained by locating some of the pressure centres of the airfoils Cp upstream and other pressure centres downstream of the variable pitch rotation axis (x), so that the torques, which are generated because of the aerodynamic forces, balance each other, thus allowing the use of a low power input to activate the variable pitch; the airfoils on the hub and at the end are disposed so as that the axis (x) coincides with the centre line of the chord,

while the other airfoils are disposed so as that, under all circumstances, the resulting torque change within a minimum value range, therefore the line that joins the (Cp) of all the blade airfoils, has a sinusoidal path (y).

9. A turbine engine according to claim 2, characterized in that, in the design phase, the stator airfoils must deviate the advancement speed V so as to generate relative speed vector W always equal, in module and in direction, in all the sections to the vector W_e closed at the end of the blade; thus in the velocity triangles, of all the rotor blades sections, angles (β) are equal in value to the angles at the end of the blade, where it has been demonstrated that there is the highest efficiency.

10. A turbine engine according to claim 4, characterized in that the stator blades positioned downstream of the rotor are formed by a fixed part and by a movable part (25).

11. A turbine engine according to claims 4 and 10, characterized in that the movable part (25) of the stator blades positioned downstream of the rotor are driven by an electric motor (24); the blades (25) have, at their free ends, projecting folded levers (26), whose axis x is rigidly connected to the rotation centre of the blades (25); the projecting ends of the levers (26) are housed in eyelets (27) obtained in the ring gear (28); said ring is linked to the

outer structure (4) of the engine by means of the shoulders (29) and of the pins (30) obtained on the outer structure; by activating the motor (24), by means of the coupling with conic gears (28 and 31), also the ring (28) rotates and, by dragging the levers (26), causes the blades (25) to rotate.

12. A turbine engine according to the previous claims, characterized in that the actuation and the control of the blades 8 and 25 are of the electric type; an electronic central unit processes, as input data, the advancement speed and the number of revolutions of the propeller and, thanks to the software with which the central unit is programmed, it drives the two electric motors which move the rotor pitch mechanisms and the pitch mechanisms of the movable stator part, respectively; the positions of the blades 8 and 25 are respectively activated through the feedback by the encoders 12 and 32 which send to the central processing unit a comparison electric signal which is proportional to the instantaneous position.

13. A turbine engine according to the previous claims, characterized in that the control of the propeller pitch is different from the control of the pitch of the stator movable part because there is the possibility to position the blade at an offset angle with respect to the position controlled by the central unit.

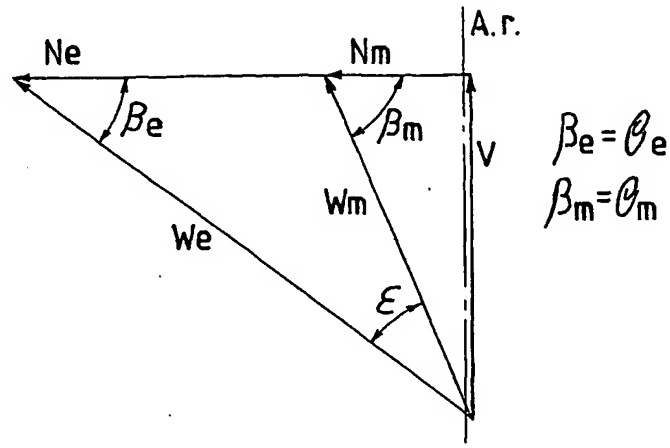


Fig.1

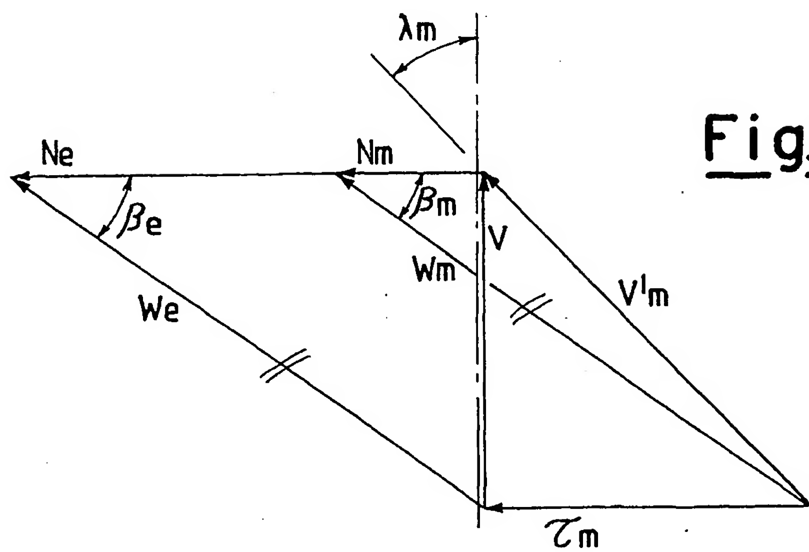


Fig.2

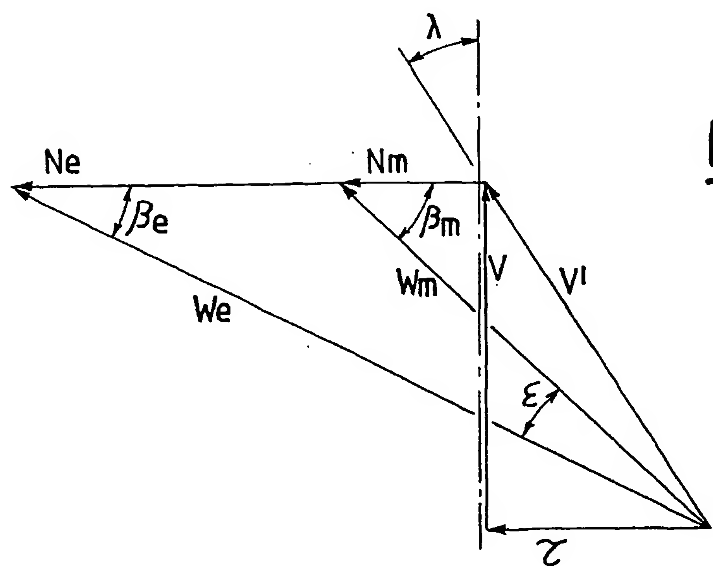


Fig.3

Fig.4

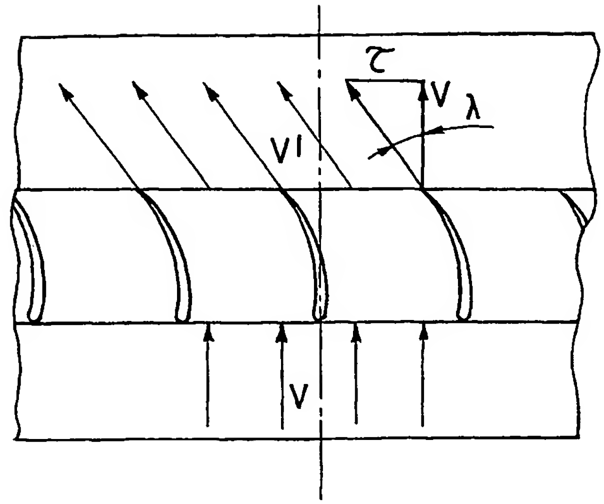


Fig.5

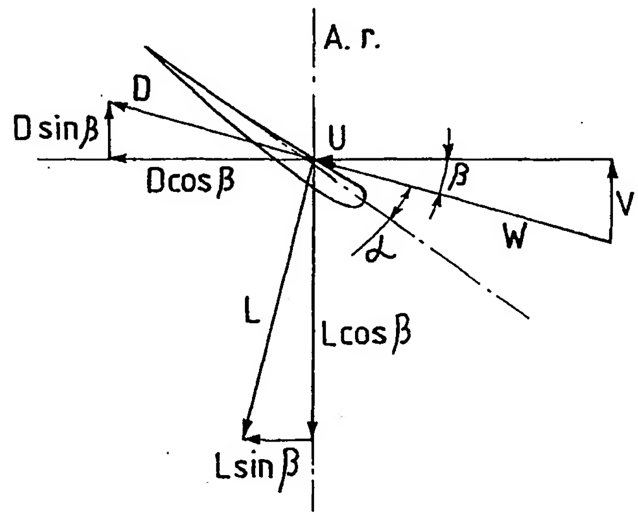
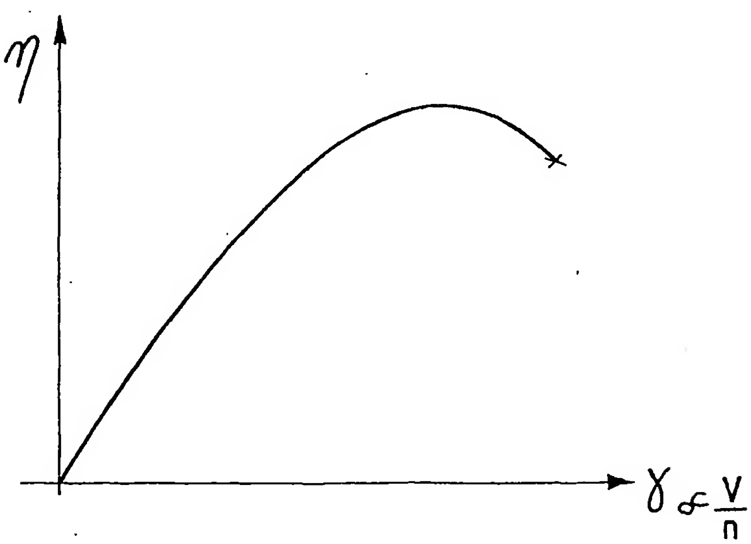


Fig.6



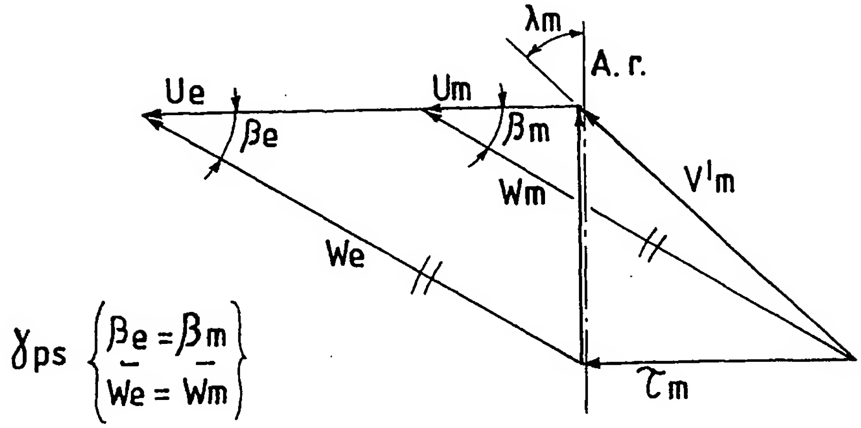


Fig.7a

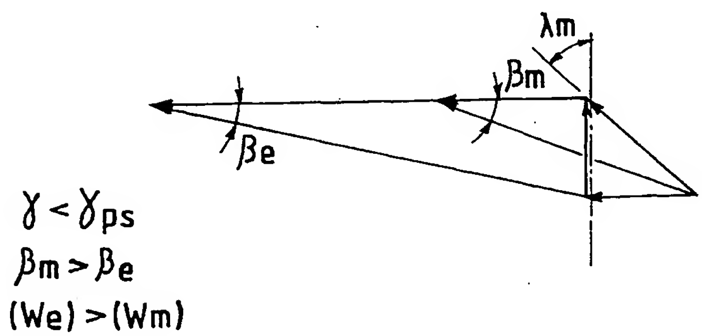


Fig.7b

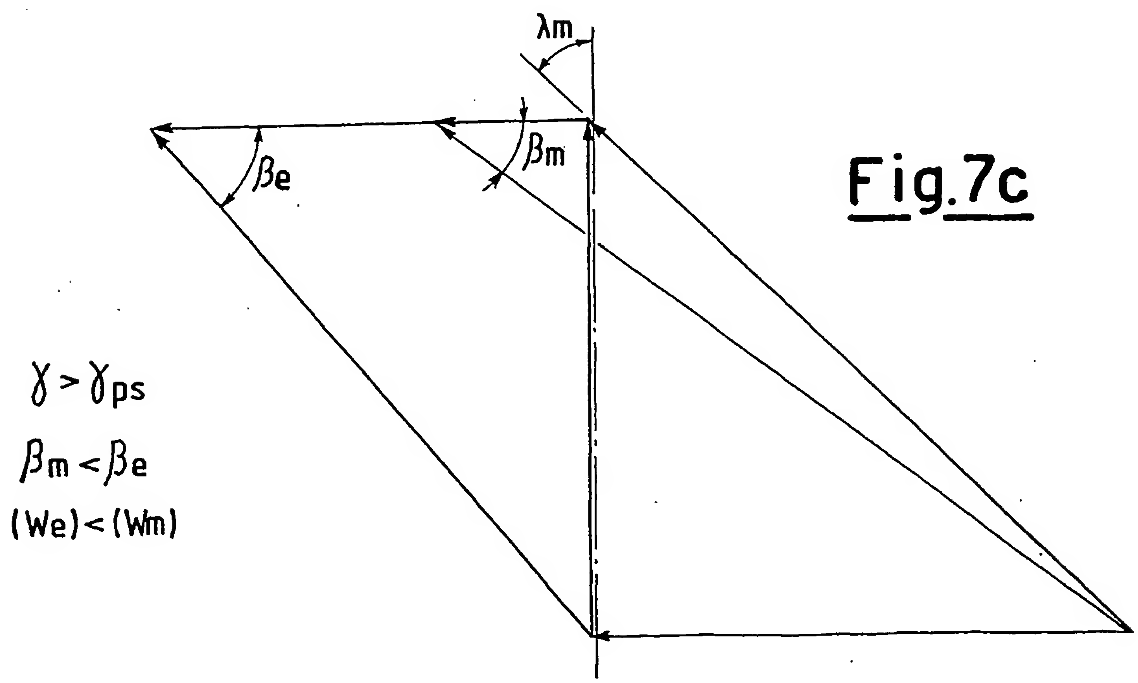


Fig.7c

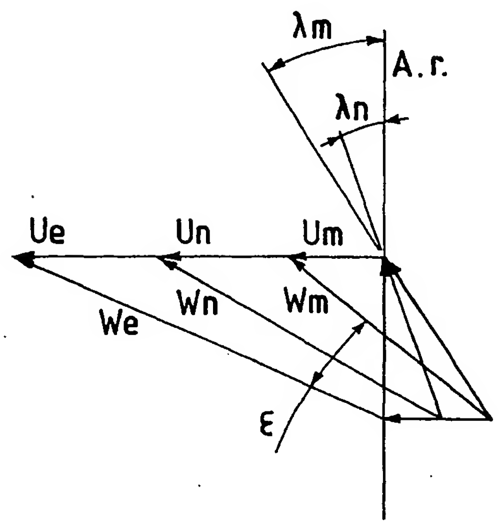
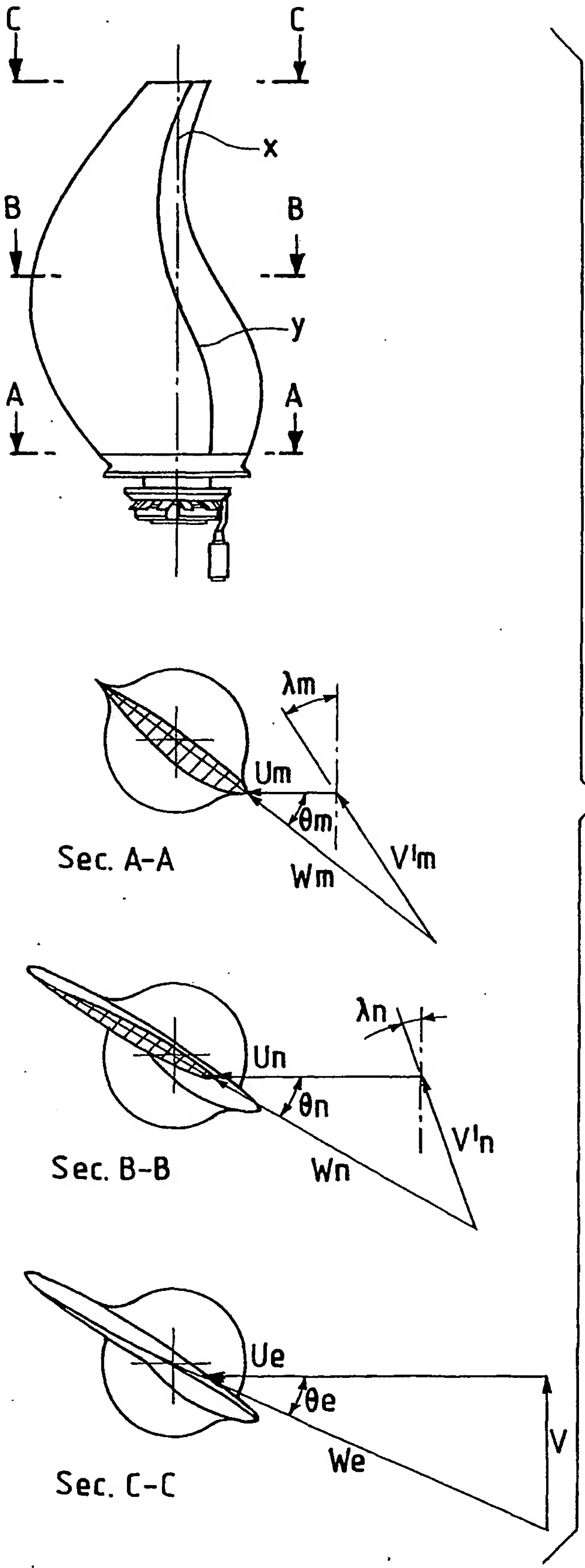

λm
A.r.
λn
Ue
Un
Um
Wn
Wm
We
ε

Fig.8b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C
x
B
B
y
A
A
λm
Um
θm
V'm
Wm
Sec. A-A
λn
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V'n
Wn
Sec. B-B
Ue
θe
V
We
Sec. C-C

Fig.8a

Fig.9c

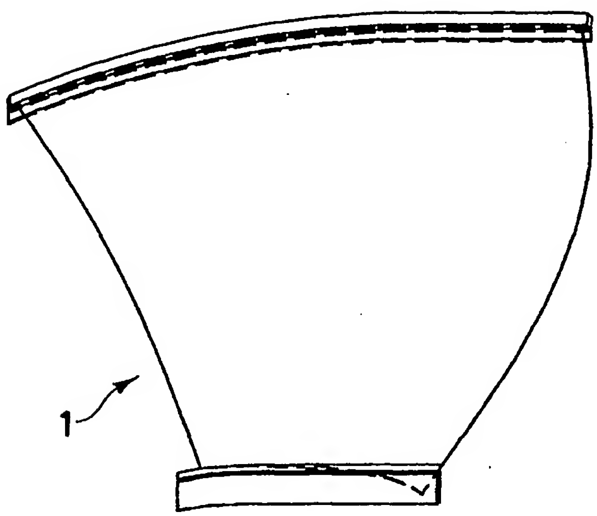


Fig.9b

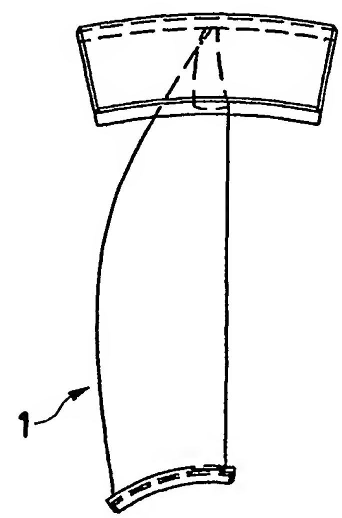


Fig.9d

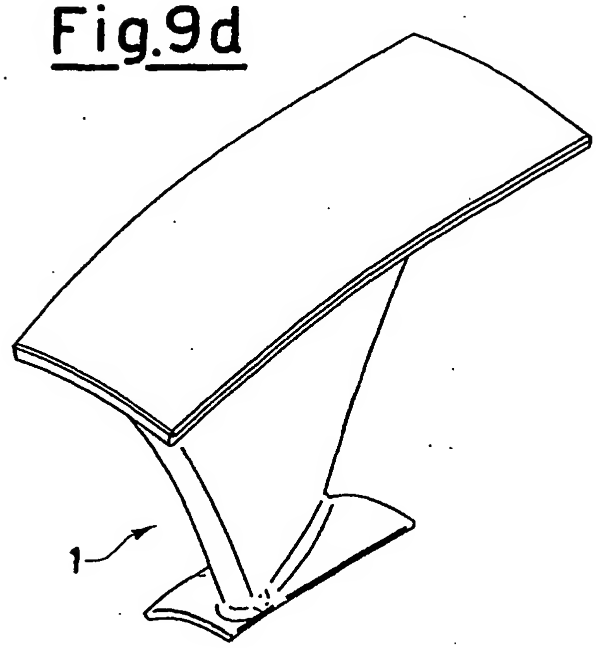


Fig.9a

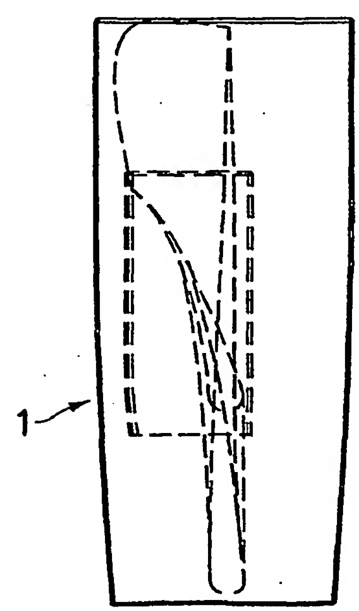


Fig.10c

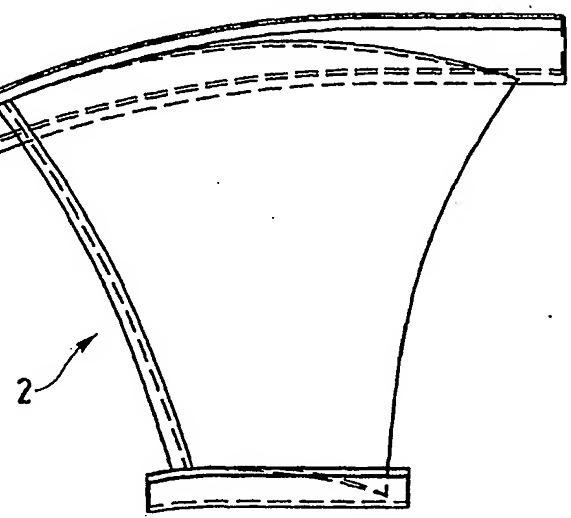


Fig.10b

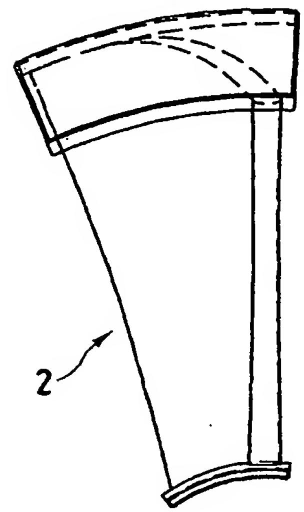


Fig.10d

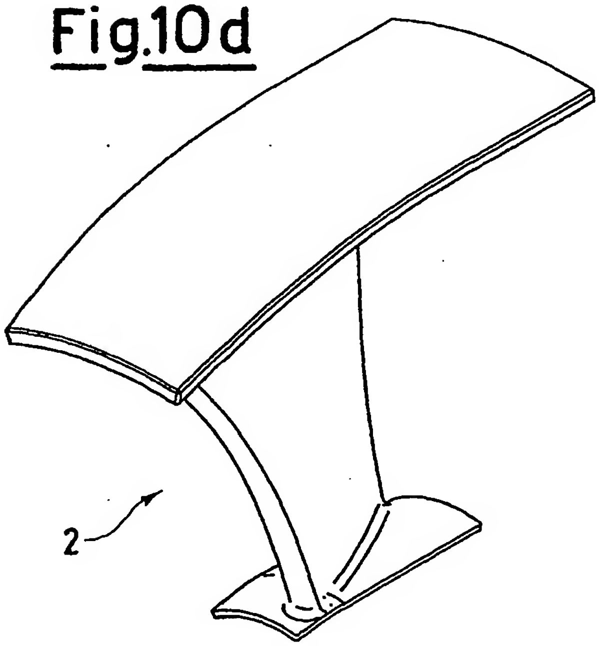
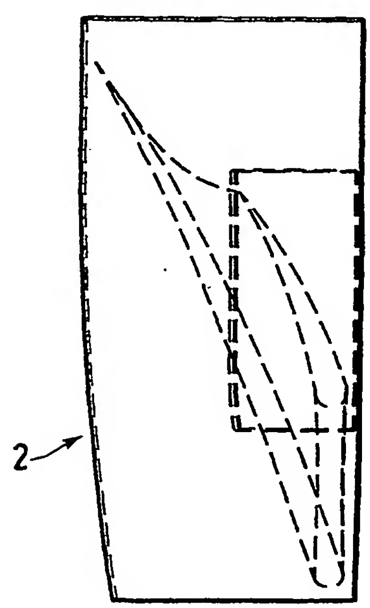


Fig.10a



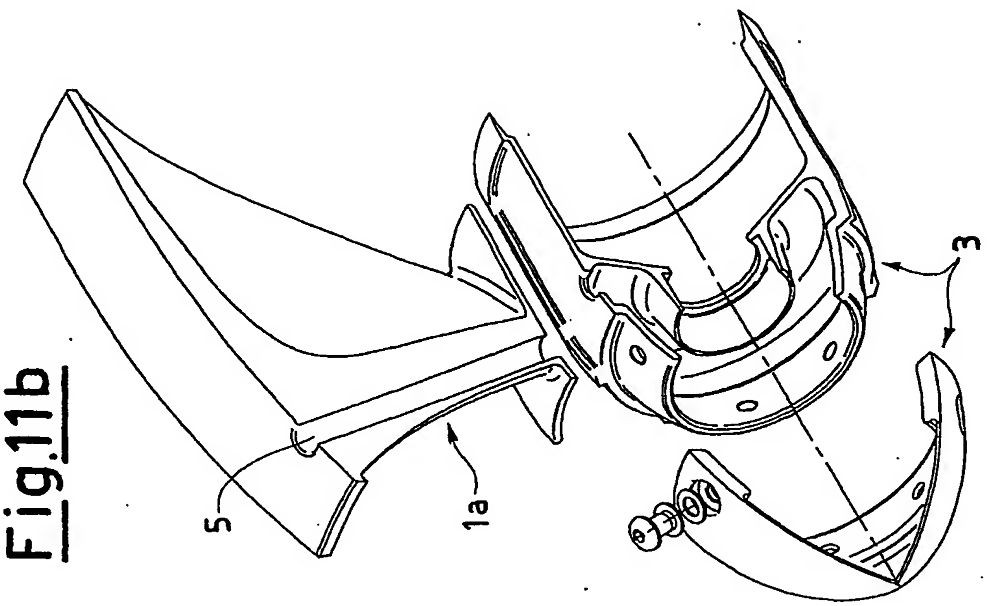


Fig.11b

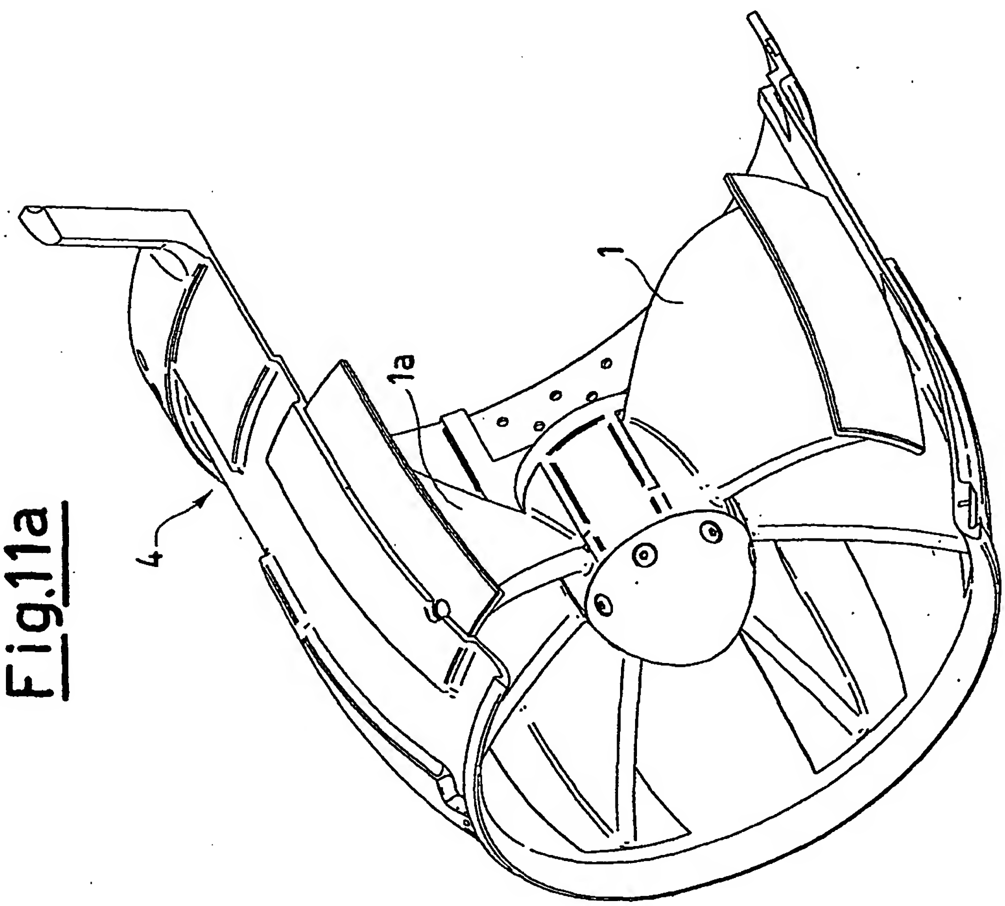


Fig.11a

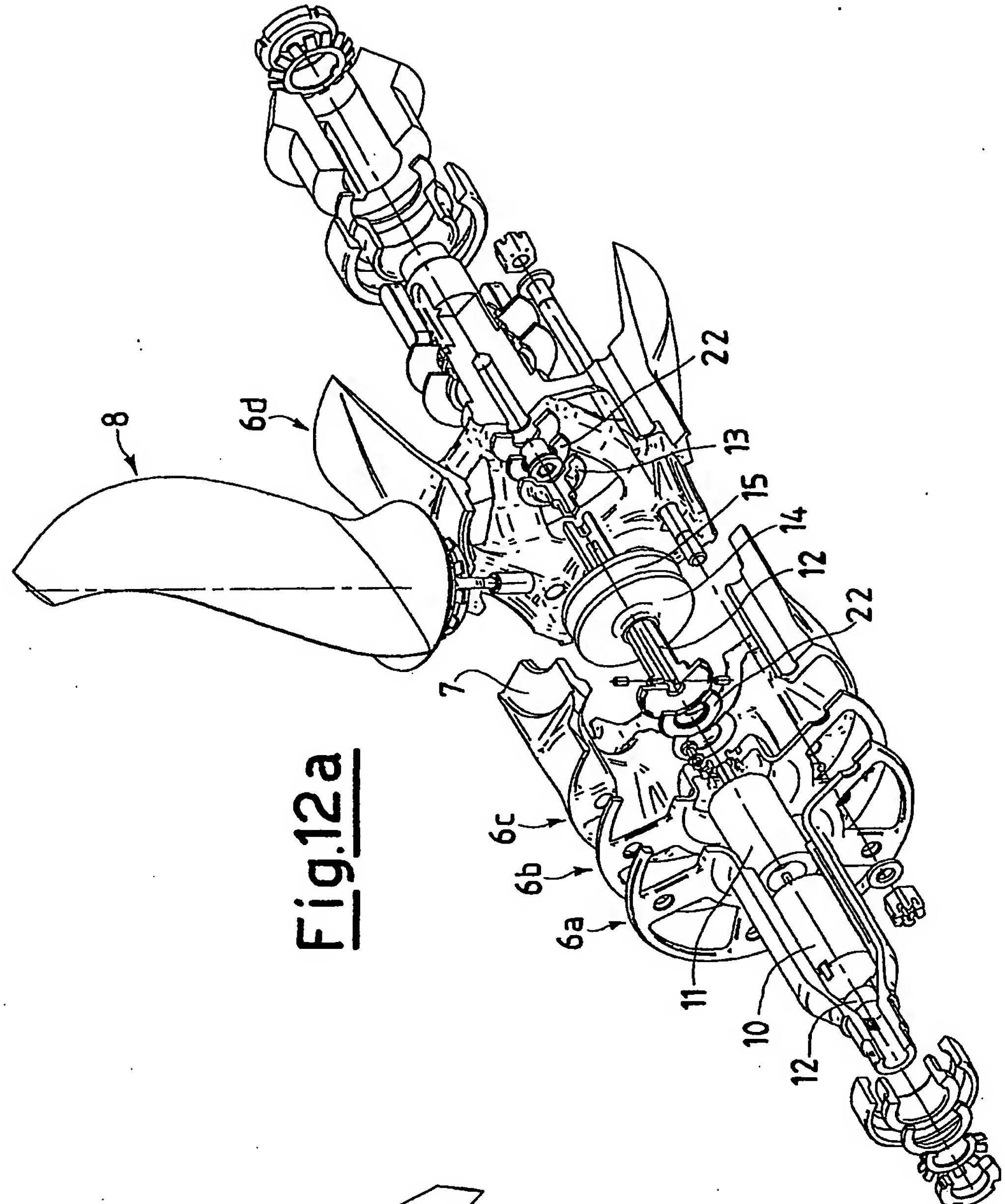


Fig.12a

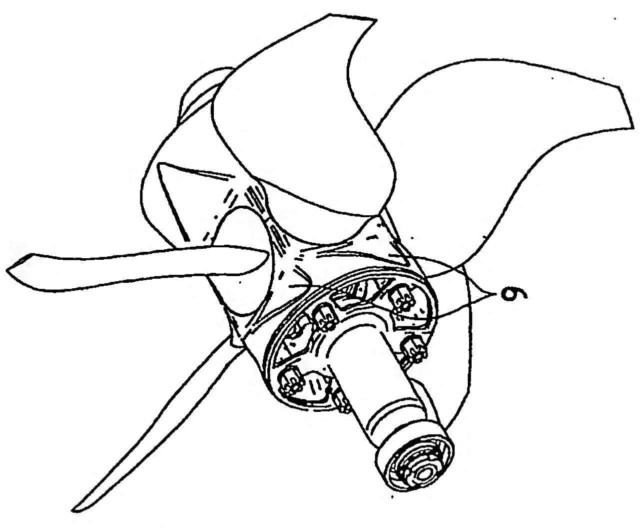


Fig.12b

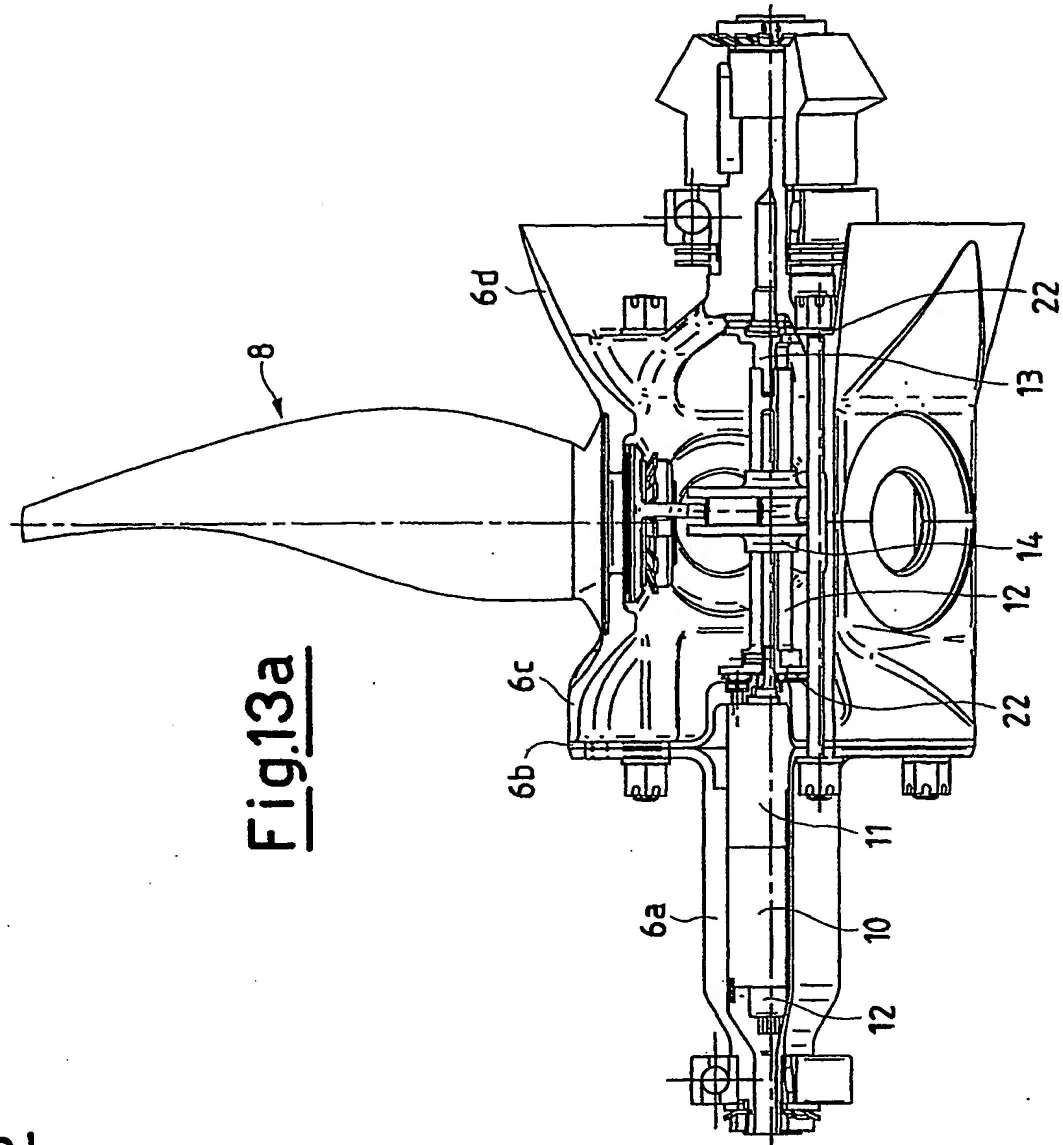


Fig.13a

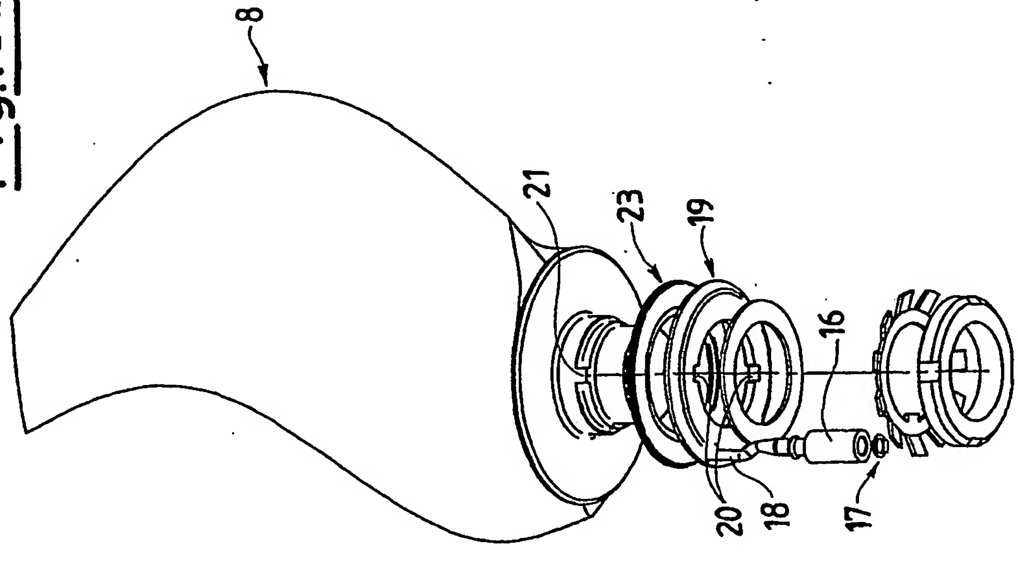


Fig.13b

Fig.14b

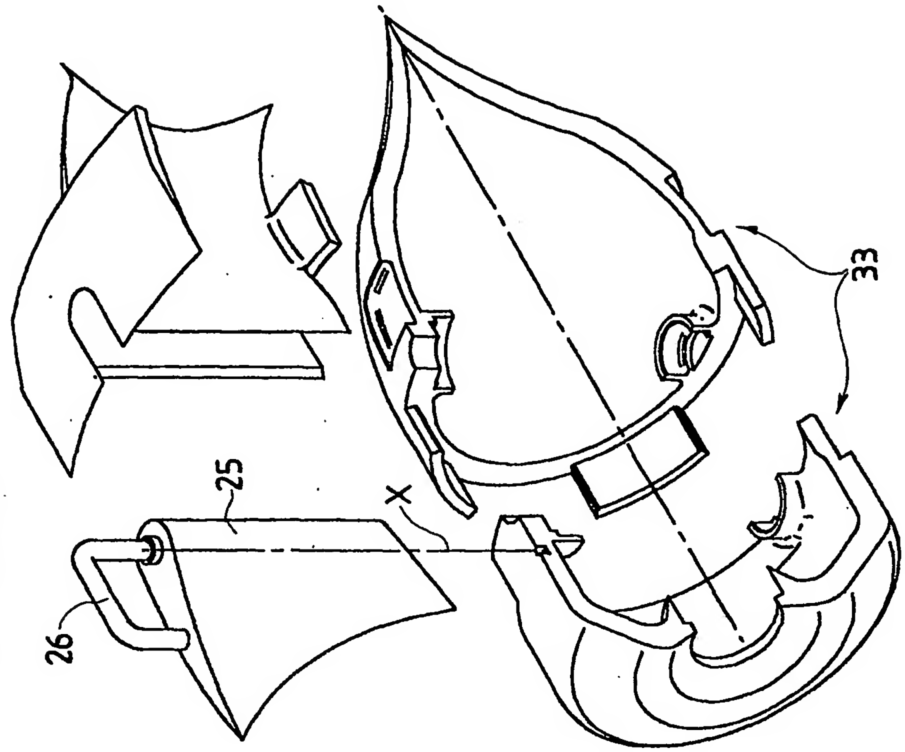
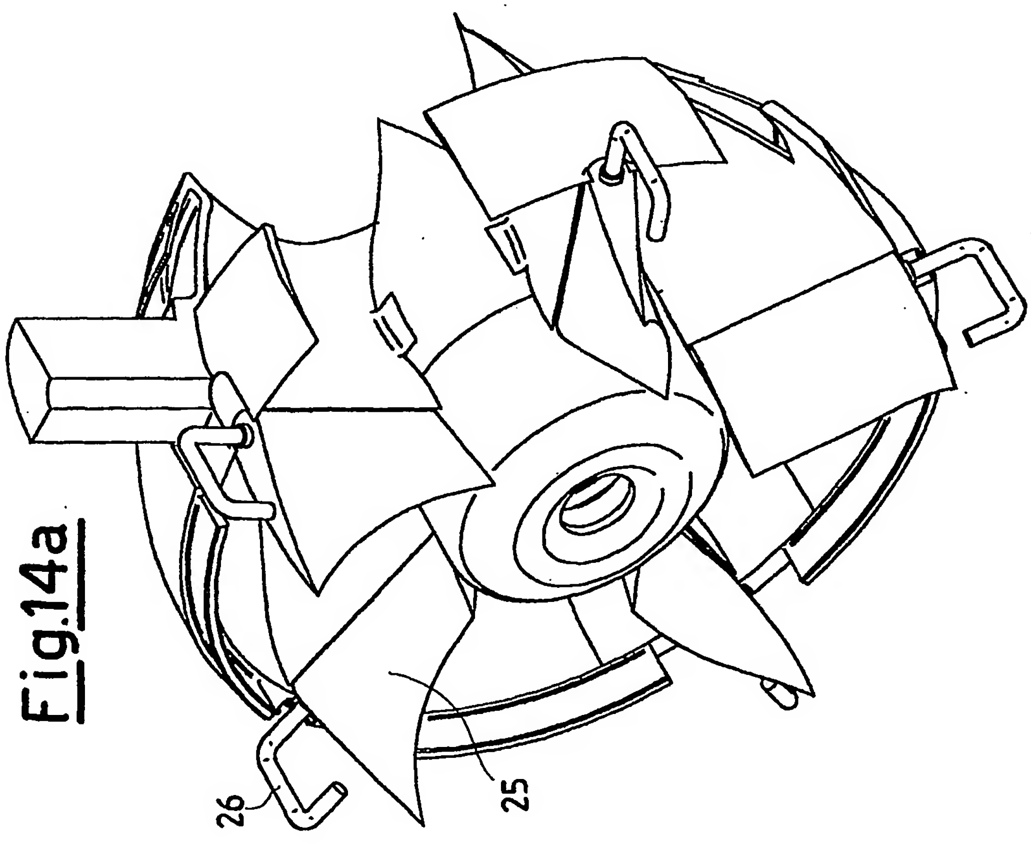


Fig.14a



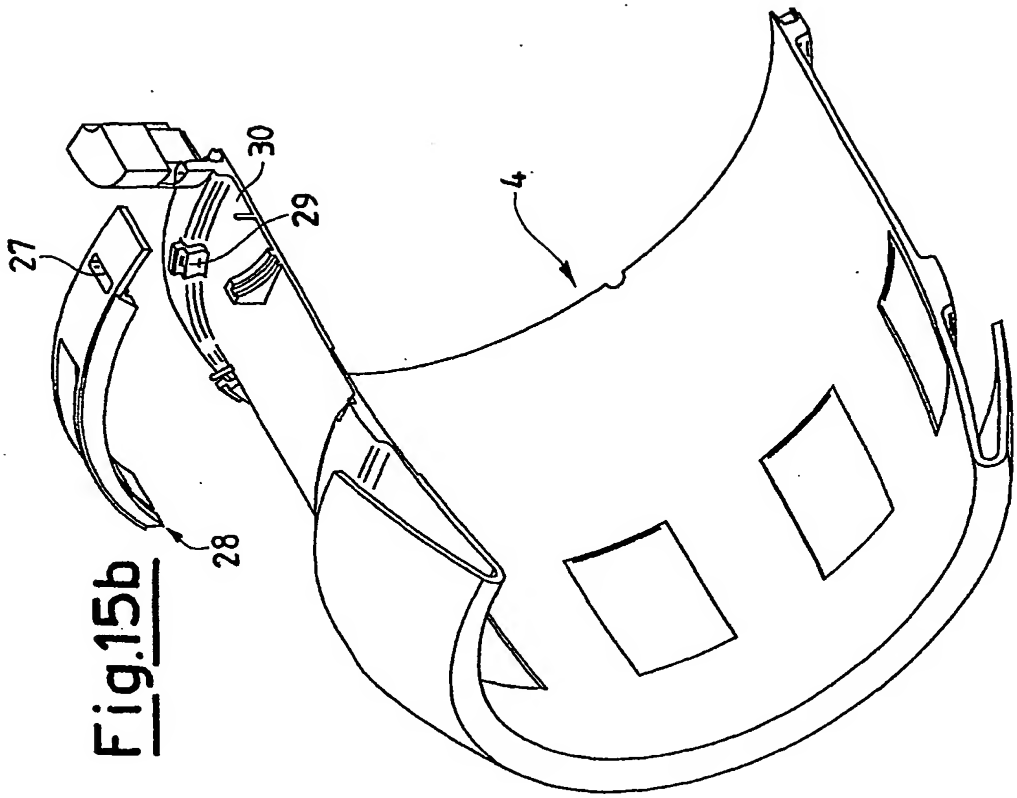


Fig.15b

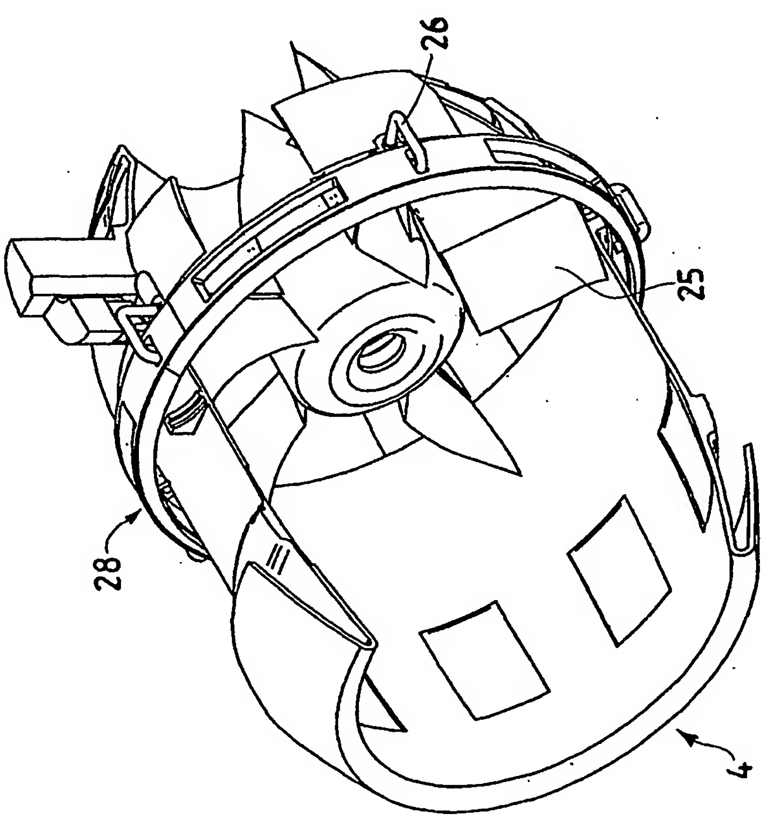


Fig.15a

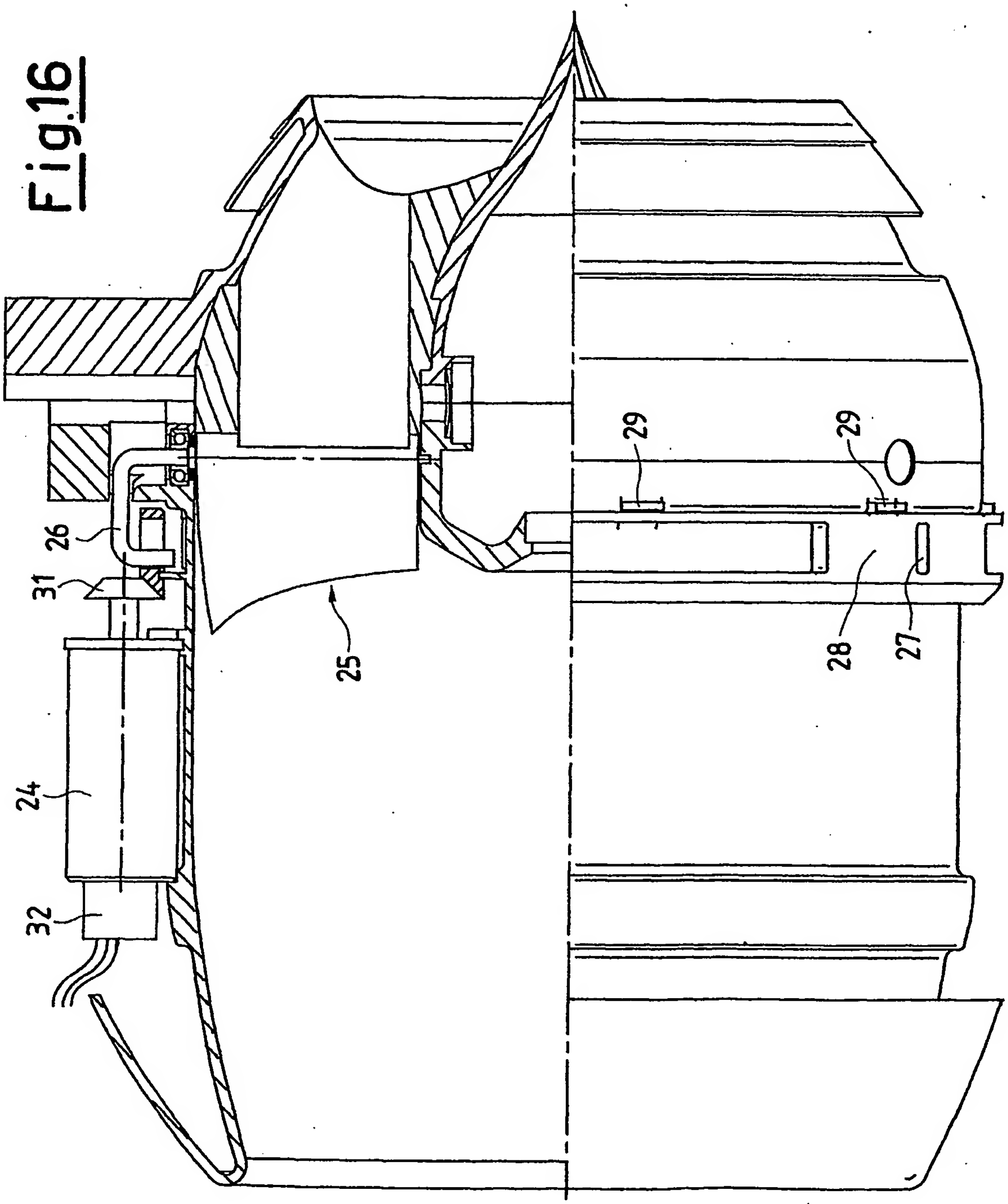


Fig.16

Fig.17b

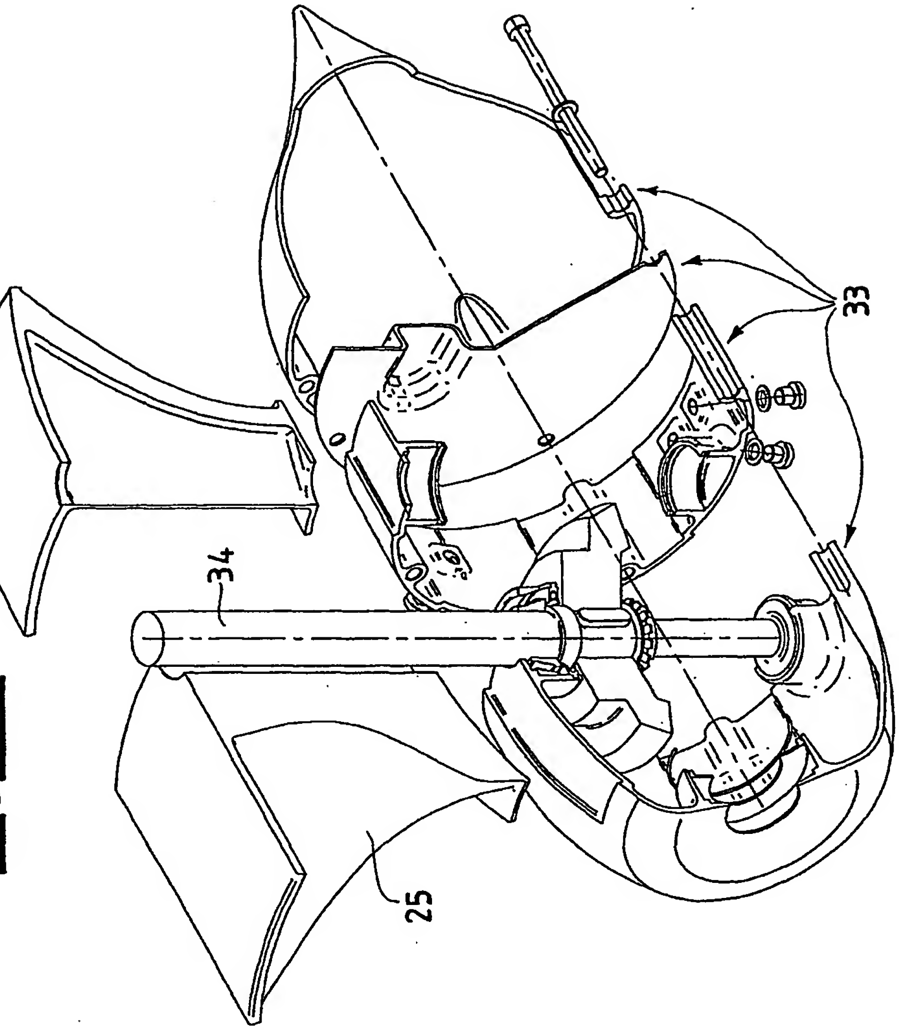


Fig.17a

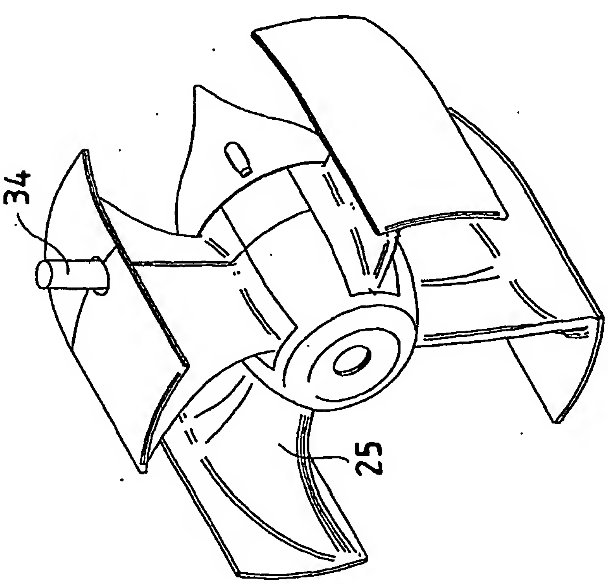


Fig.18

Variable Pitch Fan

V (m/sec)	n (rpm)	$\gamma = V/n$	η
0	11000	0,0000	0,00
10	11000	0,0009	0,72
25	11000	0,0023	0,79
50	11000	0,0045	0,82
75	9850	0,0076	0,83
100	9000	0,0111	0,82
125	8350	0,0150	0,82

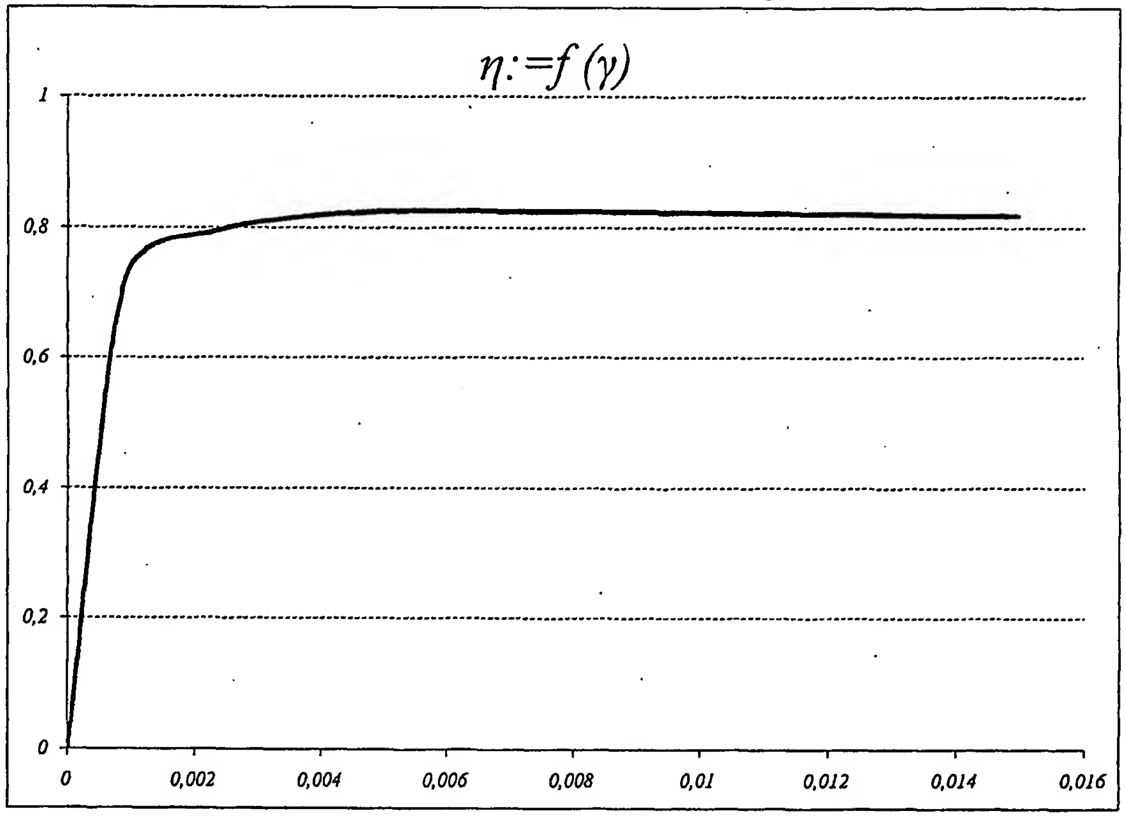


Fig.19 *Iper-Fan with "Twisted" Stator Row*

Vo (m/sec	n (rpm)	$\gamma = V/n$	η
0	11000	0,0000	0,00
10	11000	0,0009	0,66
25	11000	0,0023	0,78
50	10550	0,0047	0,85
75	8700	0,0086	0,88
100	6800	0,0147	0,91
125	5150	0,0243	0,95

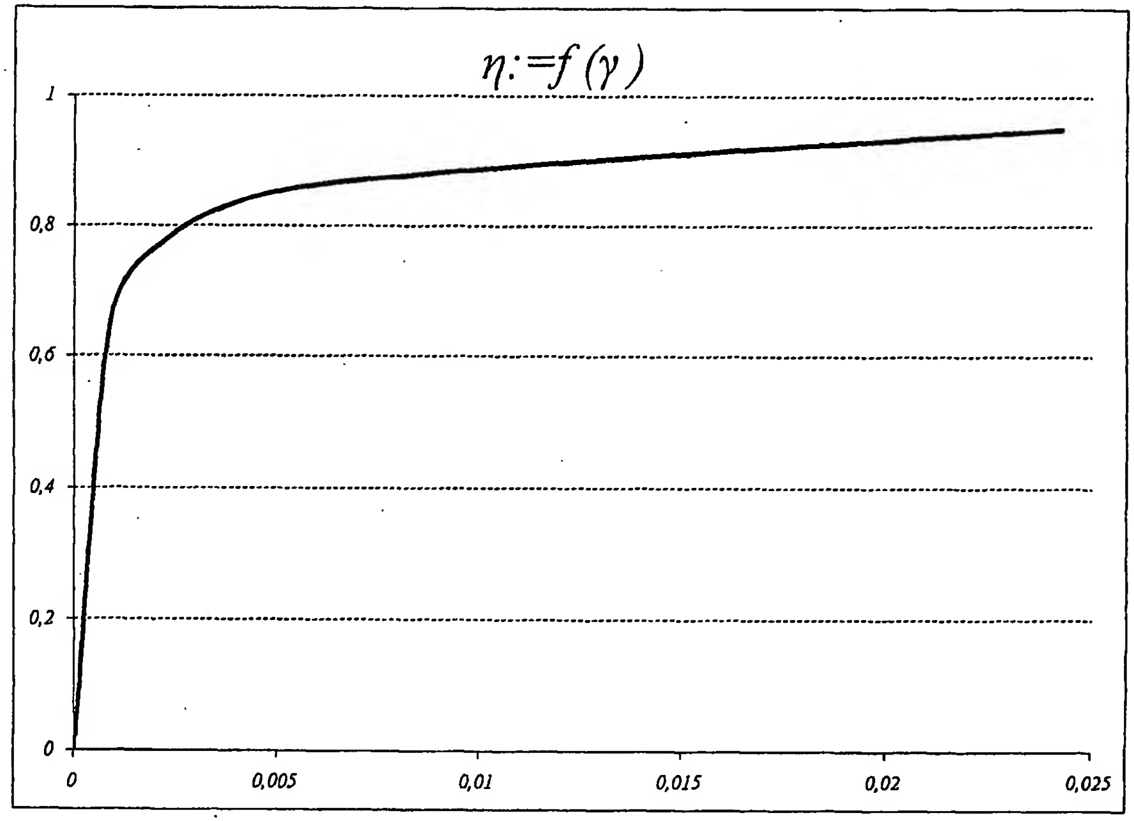


Fig.20 *Iper-Fan with "Constant Deviation" Stator Row*

V (m/sec)	n (rpm)	$\gamma = V/n$	η
0	11000	0,0000	0,00
10	11000	0,0009	0,67
25	11000	0,0023	0,79
50	9850	0,0051	0,88
75	7900	0,0095	0,92
100	6400	0,0156	0,91
125	4900	0,0255	0,86

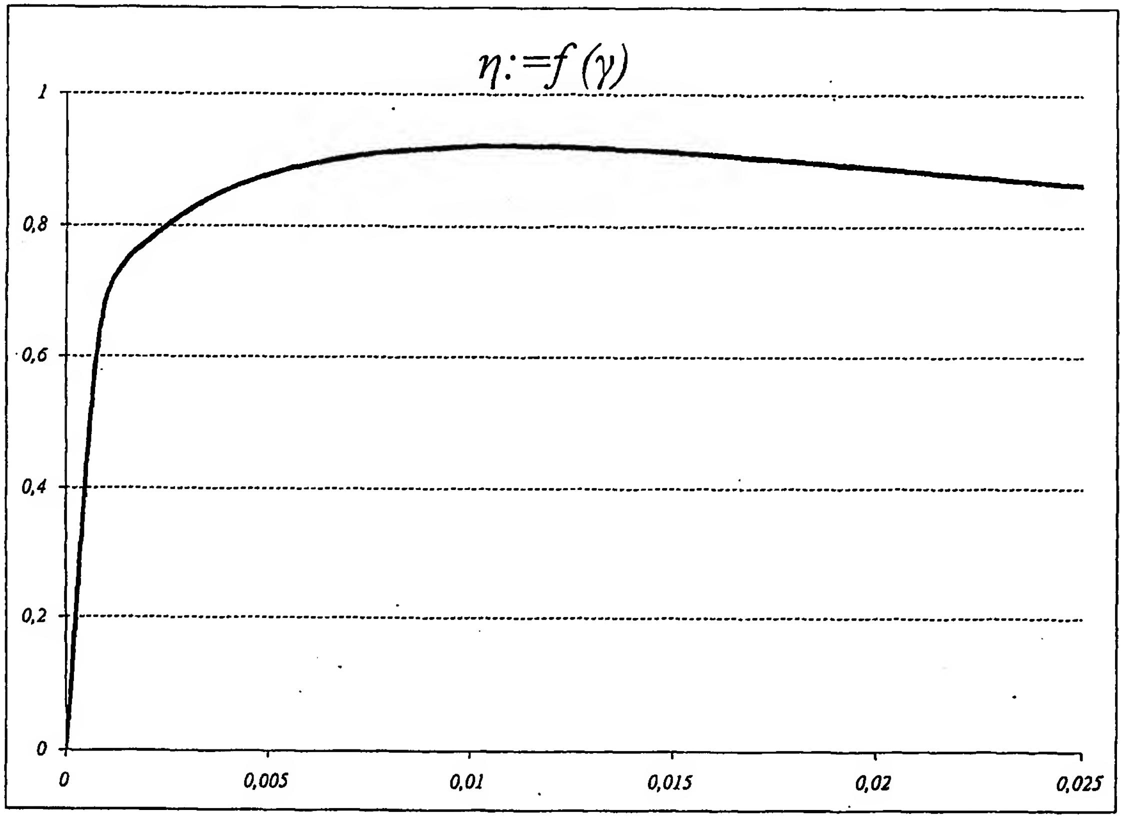
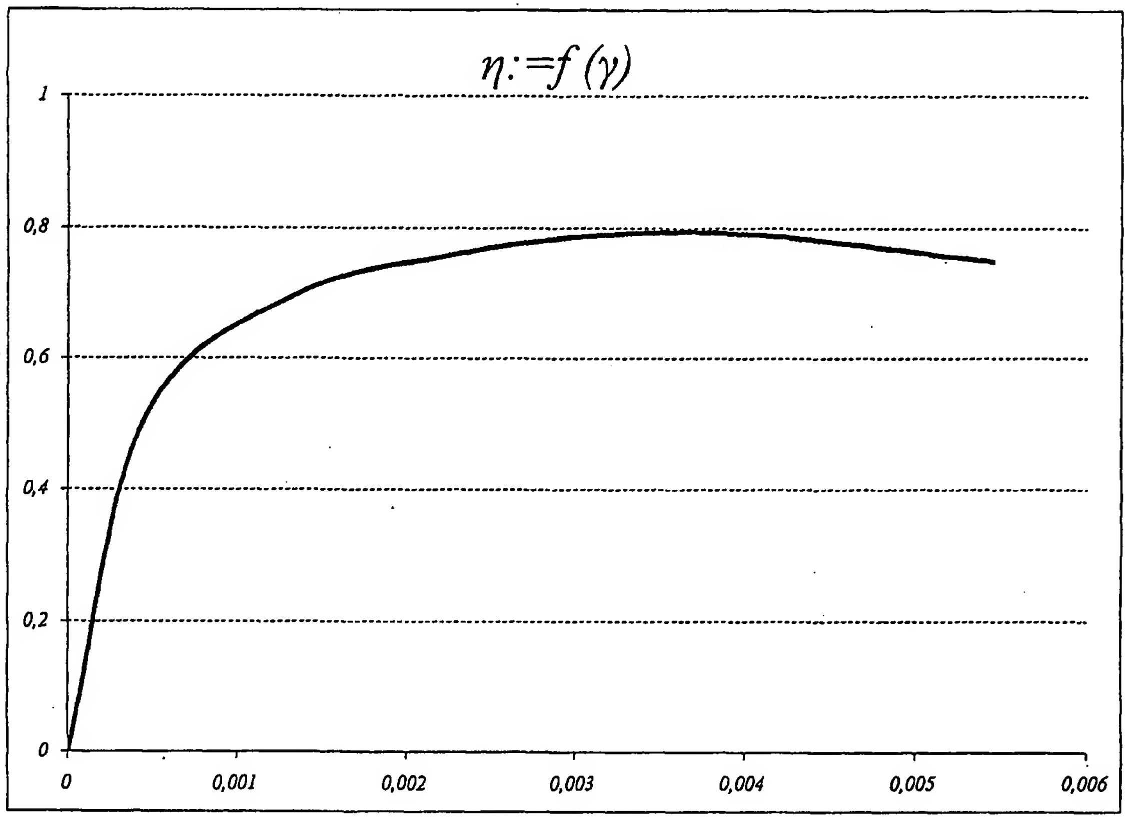


Fig.21

Fixed Pitch Fan

V (m/sec)	n (rpm)	$\gamma = V/n$	η
0	11000	0,0000	0,00
5	11000	0,0005	0,51
15	11000	0,0014	0,70
25	11000	0,0023	0,76
35	11000	0,0032	0,79
45	11000	0,0041	0,79
60	11000	0,0055	0,75



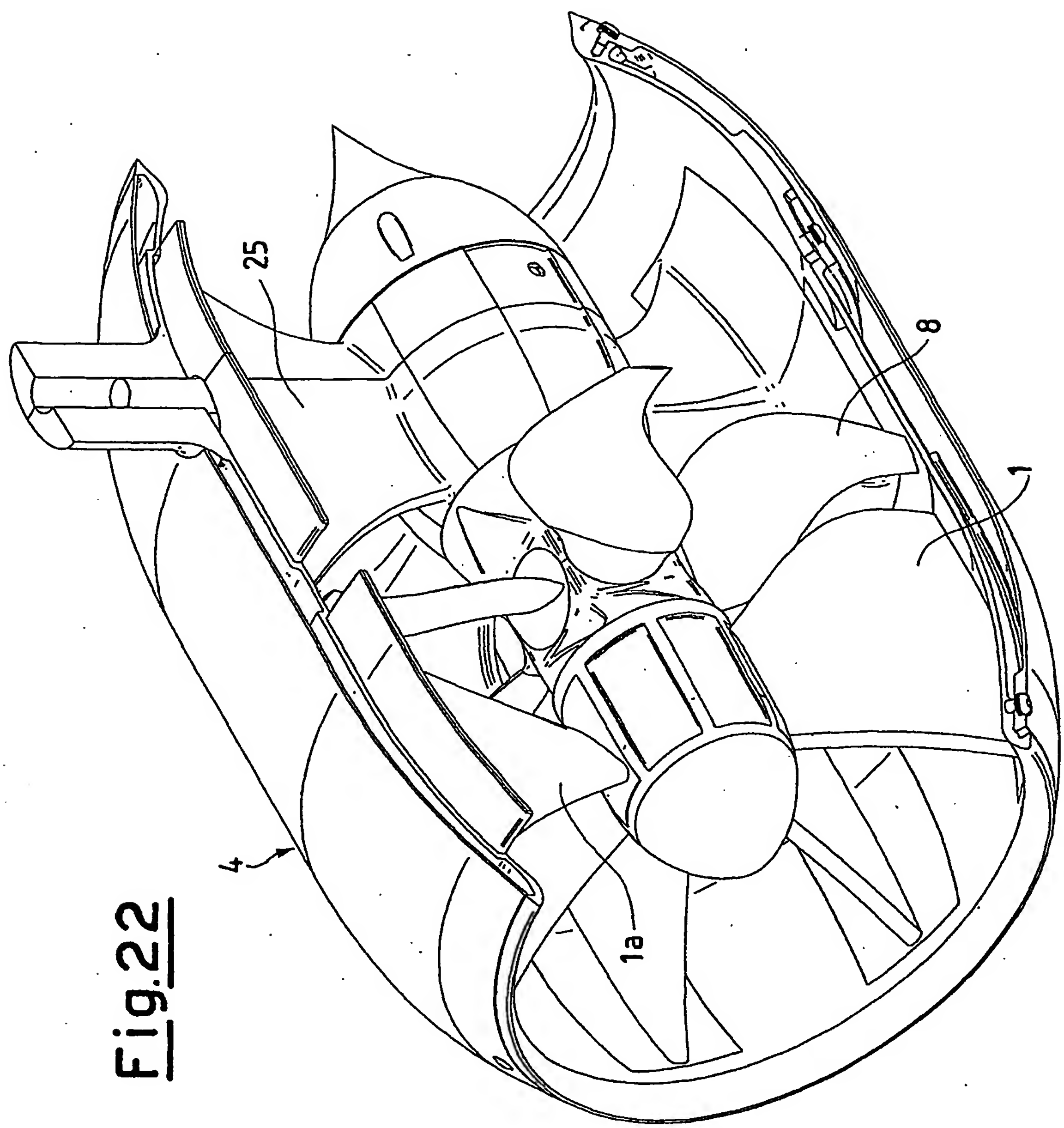


Fig.22

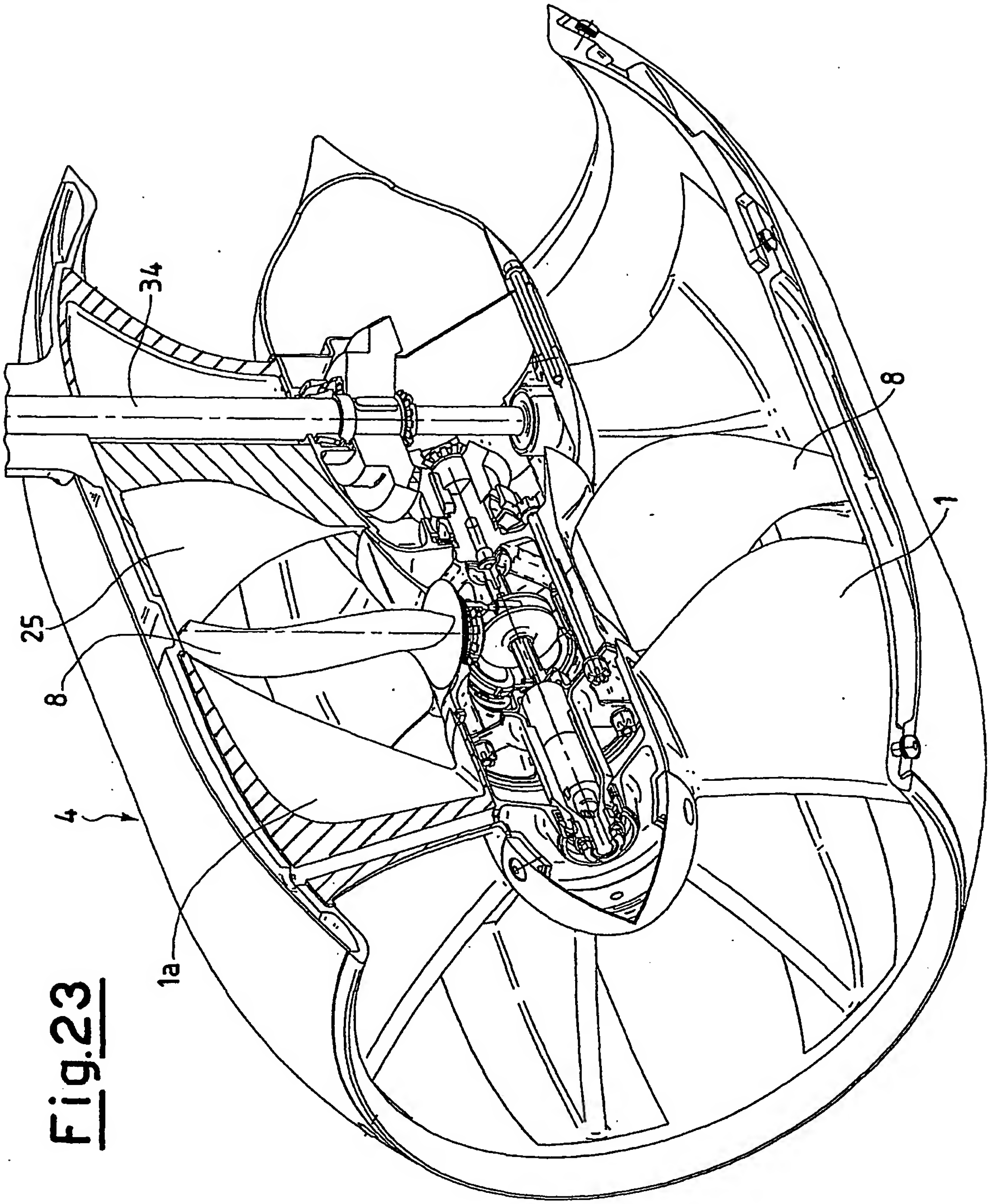


Fig.23

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 02/00132

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F01D7/00 F01D17/16

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F02C F01D B63H B64C F02K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 5 911 679 A (FARRELL WILLIAM M ET AL) 15 June 1999 (1999-06-15) the whole document	1,2,4,9 3,7,10, 11
Y A	US 6 071 076 A (SINGH ANANT P ET AL) 6 June 2000 (2000-06-06) the whole document	3 1,5,6,9, 10
Y	US 3 146 755 A (MORSE EARL P) 1 September 1964 (1964-09-01) figures 5,21,22	7
Y	US 5 794 432 A (CONVERSE GEORGE L ET AL) 18 August 1998 (1998-08-18) figure 4	10

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
22 May 2002	06/06/2002
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Authorized officer Koch, R

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INTERNATIONAL SEARCH REPORT

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
Y A	US 5 215 434 A (GROSS HELMUT ET AL) 1 June 1993 (1993-06-01) the whole document	11 10
A	WO 99 15399 A (SAMUELSSON ANDERS) 1 April 1999 (1999-04-01) the whole document	5
A	US 5 597 138 A (ARLTON PAUL E ET AL) 28 January 1997 (1997-01-28) the whole document	1,7,8
A	US 6 071 077 A (ROWLANDS PAUL A) 6 June 2000 (2000-06-06) figure 7	8

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 02/00132

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 5911679	A	15-06-1999	NONE			
US 6071076	A	06-06-2000	NONE			
US 3146755	A	01-09-1964	GB	969857	A	16-09-1964
US 5794432	A	18-08-1998	WO	9809066	A1	05-03-1998
			US	6292763	B1	18-09-2001
US 5215434	A	01-06-1993	DE	4102188	A1	06-08-1992
			FR	2672083	A1	31-07-1992
			GB	2254381	A ,B	07-10-1992
			JP	3165211	B2	14-05-2001
			JP	4303136	A	27-10-1992
WO 9915399	A	01-04-1999	SE	512824	C2	22-05-2000
			AU	732920	B2	03-05-2001
			AU	9291098	A	12-04-1999
			BR	9812486	A	26-09-2000
			CA	2304447	A1	01-04-1999
			EP	1015307	A1	05-07-2000
			JP	2001517581	T	09-10-2001
			NO	20001477	A	22-03-2000
			SE	9703466	A	26-03-1999
			WO	9915399	A1	01-04-1999
			US	6312223	B1	06-11-2001
US 5597138	A	28-01-1997	US	5628620	A	13-05-1997
			US	5305968	A	26-04-1994
			AU	686883	B2	12-02-1998
			AU	3538795	A	14-03-1996
			EP	0773881	A1	21-05-1997
			JP	10505559	T	02-06-1998
			WO	9606006	A1	29-02-1996
			US	5836545	A	17-11-1998
			US	5879131	A	09-03-1999
			AU	681287	B2	21-08-1997
			AU	2426395	A	29-11-1995
			EP	0757647	A1	12-02-1997
			JP	9512515	T	16-12-1997
			WO	9529842	A2	09-11-1995
			US	5609312	A	11-03-1997
			US	5906476	A	25-05-1999
			DE	69221307	D1	04-09-1997
			DE	69221307	T2	19-02-1998
			EP	0605656	A1	13-07-1994
			JP	6510969	T	08-12-1994
			WO	9307054	A1	15-04-1993
US 6071077	A	06-06-2000	EP	0801230	A2	15-10-1997